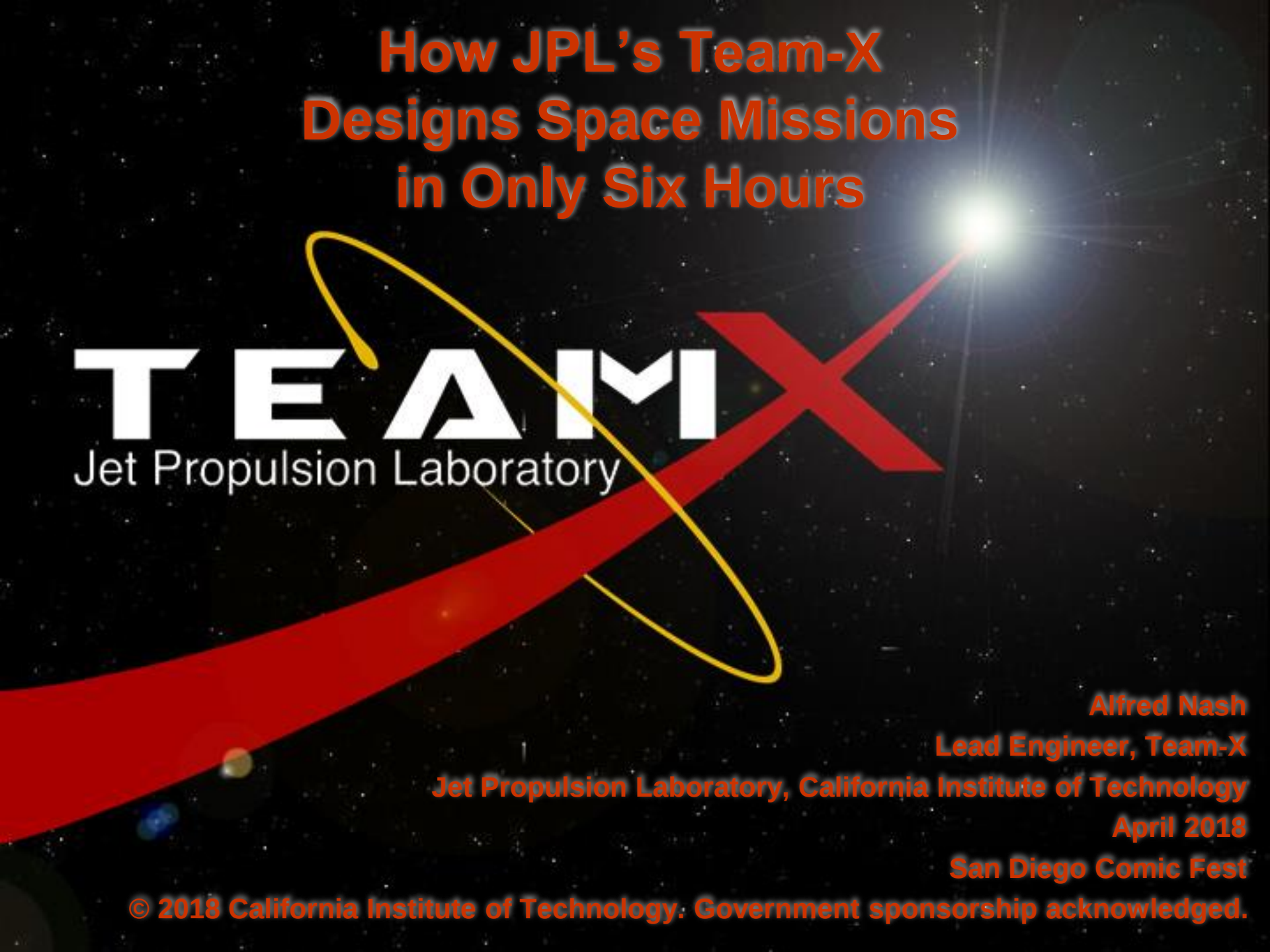
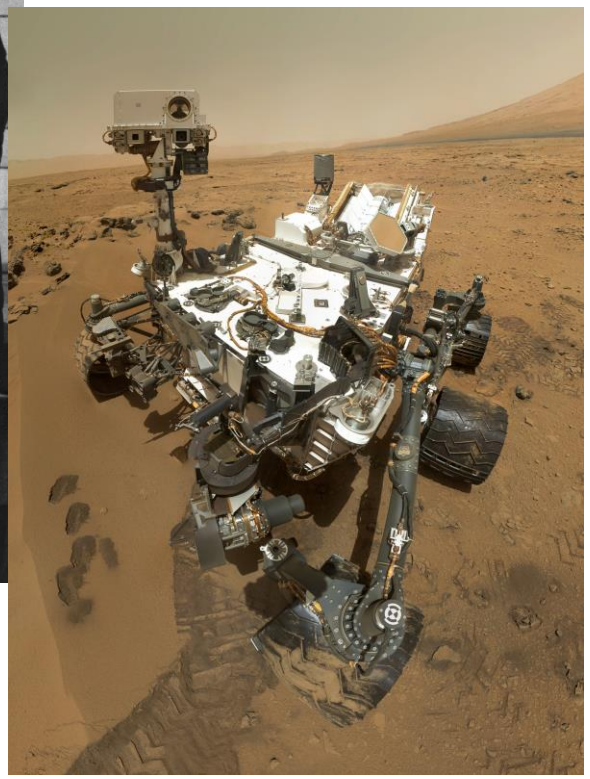
How JPL's Team-X Designs Space Missions in Only Six Hours



Alfred Nash
Lead Engineer, Team-X
Jet Propulsion Laboratory, California Institute of Technology
April 2018
San Diego Comic Fest

Jet Propulsion Laboratory

Jet Propulsion Laboratory
California Institute of Technology



Why a Team-X?

NASA Conducts Business Two Ways

Directed

Competed

Keep your mind on where you are. What you are doing.

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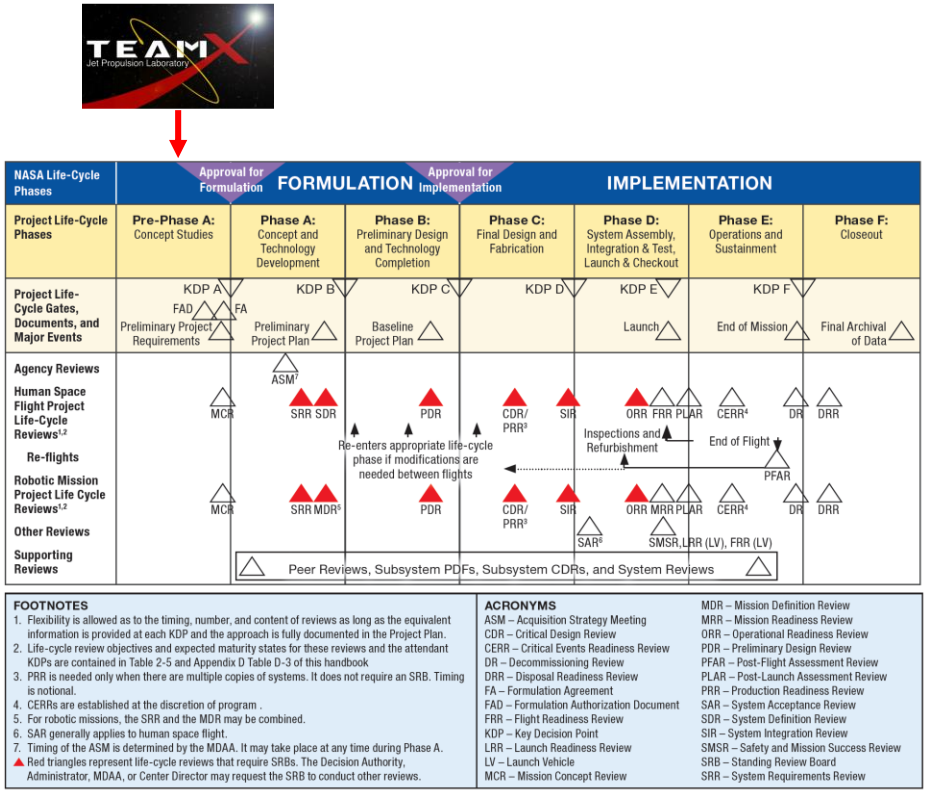


FOOTNOTES

1. Flexibility is allowed as to the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan.
2. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-5 and Appendix D Table D-3 of this handbook
3. PRR is needed only when there are multiple copies of systems. It does not require an SRB. Timing is notional.
4. CERRs are established at the discretion of program .
5. For robotic missions, the SRR and the MDR may be combined.
6. SAR generally applies to human space flight.
7. Timing of the ASM is determined by the MDAA. It may take place at any time during Phase A.

▲ Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB to conduct other reviews.

ACRONYMS

ASM – Acquisition Strategy Meeting
CDR – Critical Design Review
CERR – Critical Events Readiness Review
DR – Decommissioning Review
DRR – Disposal Readiness Review
FA – Formulation Agreement
FAD – Formulation Authorization Document
FRR – Flight Readiness Review
KDP – Key Decision Point
LRR – Launch Readiness Review
LV – Launch Vehicle
MCR – Mission Concept Review
MDR – Mission Definition Review
MRR – Mission Readiness Review
ORR – Operational Readiness Review
PDR – Preliminary Design Review
PFAR – Post-Flight Assessment Review
PLAR – Post-Launch Assessment Review
PRR – Production Readiness Review
SAR – System Acceptance Review
SDR – System Definition Review
SIR – System Integration Review
SMSR – Safety and Mission Success Review
SRB – Standing Review Board
SRR – System Requirements Review

FIGURE 3.0-1 NASA Space Flight Project Life Cycle from NPR 7120.5E

TABLE 2.2-1 Project Life Cycle Phases

Phase		Purpose	Typical Outcomes
Pre-Formulation	**Pre-Phase A** Concept Studies	To produce a broad spectrum of ideas and alternatives for missions from which new programs/projects can be selected. Determine feasibility of desired system, develop mission concepts, draft system-level requirements, assess performance, cost, and schedule feasibility; identify potential technology needs, and scope.	Feasible system concepts in the form of simulations, analysis, study reports, models, and mock-ups
Formulation	**Phase A** Concept and Technology Development	To determine the feasibility and desirability of a suggested new system and establish an initial baseline compatibility with NASA's strategic plans. Develop final mission concept, system-level requirements, needed system technology developments, and program/project technical management plans.	System concept definition in the form of simulations, analysis, engineering models and mock-ups, and trade study definition
	Phase B Preliminary Design and Technology Completion	To define the project in enough detail to establish an initial baseline capable of meeting mission needs. Develop system structure end product (and enabling product) requirements and generate a preliminary design for each system structure end product.	End products in the form of mock-ups, trade study results, specification and interface documents, and prototypes
Implementation	**Phase C** Final Design and Fabrication	To complete the detailed design of the system (and its associated subsystems, including its operations systems), fabricate hardware, and code software. Generate final designs for each system structure end product.	End product detailed designs, end product component fabrication, and software development
	Phase D System Assembly, Integration and Test, Launch	To assemble and integrate the system (hardware, software, and humans), meanwhile developing confidence that it is able to meet the system requirements. Launch and prepare for operations. Perform system end product implementation, assembly, integration and test, and transition to use.	Operations-ready system end product with supporting related enabling products
	Phase E Operations and Sustainment	To conduct the mission and meet the initially identified need and maintain support for that need. Implement the mission operations plan.	Desired system
	Phase F Closeout	To implement the systems decommissioning/disposal plan developed in Phase E and perform analyses of the returned data and any returned samples.	Product closeout

- **Only go down to the sub-system level, for *one* self consistent solution, and…**
  - Start with a Plan
  - Pre-Work "Tall Poles"
  - Work Concurrently *& Collaboratively* using a Systems Approach
  - Report your work
  - Infrastructure Helps

Start with a Plan

- **WHY**
  - Start with a one sentence purpose for the study that addresses the next step.
- **HOW**
  - Outline a top level approach with a beginning, a middle, and an end.
- **WHAT**
  - What (information) is the Client going to provide Team-X?
    - *All* boundary conditions: Technical, Economic, Political,…
  - What (information) is Team-X going to provide the Client?
    - Words, Numbers, Pictures,…
- **WHO**
  - Which sub-system level Subject Matter Experts are needed?
- **WHEN**
  - How many (3 hour) sessions? Which days?
- **WHERE**
  - Which Team-X design room will be used?
- **WHEREWITHAL**
  - How much will the study cost?

Pre-Work "Tall Poles"

- **Identify and work any system drivers that are going to hold up <u>all subsystem</u> work**
  - Planetary Science
    - Mission Design
  - Astrophysics
    - Observing Scenario
  - Earth Science
    - How Coverage Requirements Will Be Met

Systems Approach

Client Brief

Debrief Client

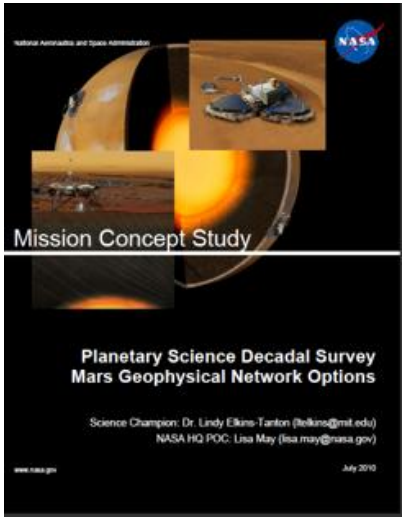
Allocate

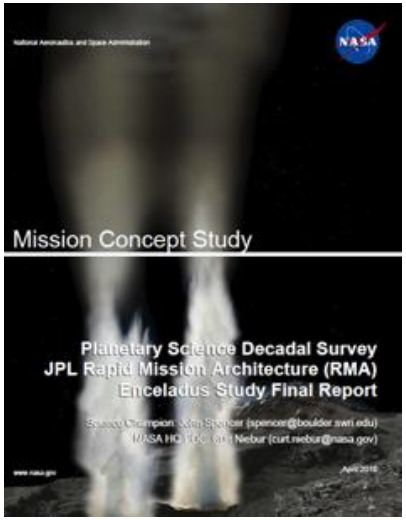
DESIGN

Verify

Reporting

- **Problem Definition**
  - Requirements, Assumptions, etc.
- **Design Description (one section per subsystem)**
  - Structural & Behavioral
  - Trades Considered, Subsystem Options Explored
  - (Technical & Financial) Resources Required
- **Evaluation**
  - Strengths, Weaknesses, Opportunities, and Threats





Information Infrastructure

- **People**
  - Especially “People Wrangler”
  - Staffed from “Doing Organizations”
- **Processes & Procedures**
  - Facilitation methods
- **Tools**
  - Databases
  - Calculators
- **Facilities**
  - “Theater” with resource “clusters”
- **Technology**
  - Networked Computers & Servers

Questions?